MAGNETISM AND SUPERCONDUCTIVITY OF SOME Tl-Cu OXIDES

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Many copper-oxide based "Thallium" compounds have now been discovered. Of these, the high temperature superconductors (HTSC) may be represented by the homologous series $(Tl_{1-x}A_xO)_m$-$(B_{1-v}C_y)_nCa_{p-1}Cu_pO_{2(p+1)+d}$; if A=Bi or Pb, B=Ba or Sr(5), C=Ce, Zr or Nd; n=2 and p=1-4. In comparison to the Bi-compounds, the Tl-system shows a richer diversity; viz., HTSC can be obtained with either one or two Tl-O layers (m=1,2); also, the triple-digit phases are easier to synthesize. The value of d, the oxygen stochiometry, is critical to achieving superconductivity. The Tl-system is robust to oxygen loss; Tl may be lost or incorporated by diffusion. We determine a diffusion coefficient equal to 10 m s at 900C. Both ortho-rhombic and tetragonal structures are evidenced, but HTSC behavior is indifferent to the crystal symmetry. This system has the highest Tc confirmed. Tc generally increases with p, the number of Cu-O layers, but tends to saturate at p=3. Zero resistance as high as 125K has been observed (1). Most of these HTSC's are hole type, but the Ce-doped specimens may be electronic.

The effort at USC has focused on the magnetic aspects; because in addition to defining the perfectly diamagnetic groundstate as in the conventional superconductors, magnetism of the copper oxides (1) show a surprising variety. This is true of both the normal and the superconducting states. Also, due to the large phonon contribution to the specific heat at the high Tc, accurate thermal measurement of important parameters such as the sp. heat jump, electronic density of states, D(Ef) and coherence length are uncertain, and thus, are estimated from the magnetic results.

We determine for single phase: (i) Tl-Ba; D(Ef)=2.0 states/ev.at. Cu, a BCS sp. ht. jump=6.2 mj/mol.Cu K; and (ii) Tl-(Ba,Ce); D(Ef)=2.2 and a BCS sp. ht. jump=6.8 (same units). For both, the Cu moment is about 0.1-0.4 Bohr mag. The Ce moment is 1.5, representing a charge state higher than 3+. This is indicative of electron doping and is evidence for n-type behavior. Paraconductivity and diamagnetic fluctuations are consistent with the expected two-dimensionality. Flux creep shows trapping potential somewhat stronger than those in Y-123. These and other results from the Tl-system Cu-O, LaBaCu-O,120 and the Bi-CuO compounds will be discussed. The emphasis will be on the role of magnetism in the Tl-CuO HTSC, but technological aspects will also be pointed out.

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(1) Copper Oxide Superconductors, by C.P. Poole, T. Datta, and H.A. Farach, John Wiley & Sons, New York, NY, 1988.